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THESIS

METHODOLOGY FOR IDENTIFYING AND QUANTIFYING THE CRITICALITY OF HUMAN FACTORS DEFICIENCIES IN NAVAL AIRCRAFT COCKPITS

by

James Francis Mowbray

March 1977

Thesis Advisors: Douglas E. Neil
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METHODOLOGY FOR IDENTIFYING AND QUANTIFYING THE CRITICALITY OF HUMAN FACTORS DEFICIENCIES IN NAVAL AIRCRAFT COCKPITS

by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

Human factors and system safety engineering concepts frequently have not been incorporated in the design of U. S. Navy aircraft cockpits. The relationship of human factors cockpit deficiencies to pilot error and operator inefficiency is examined and the need for a comprehensive data base of these deficiencies is demonstrated. A questionnaire was designed and developed to collect the required data from the operators of naval aircraft. Results from administering the questionnaire to a number of subjects substantiate the validity of the method for gathering the human factors cockpit deficiency data. Recommendations are made for expanding the data collection to a Navy-wide basis.

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I. INTRODUCTION

The importance of the inclusion of Human Factors Engineering in the design of Naval systems has been recognized for some time, and in 1968, MIL-H-46855, Human Engineering Requirements for Military Systems, Equipment, and Facilities, was published, thus formalizing anew this importance. Concurrently, MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, was published. MIL-STD-1472 established the criteria for and MIL-H-46855 mandated the application of human engineering to Navy systems acquisitions. Similarly, MIL-STD-882, System Safety Program for Systems and Associated Subsystems and Equipment, established the requirements and mandated the application of system safety to Navy acqisitions. Since their promulgation, these publications have been superseded by updated versions and it appears that human engineering requirements and design criteria are continually being strengthened. Yet Casey and Sturm(1974), after documenting the existence of the formal requirement for designing human engineering into Navy systems, presented prominent examples of human engineering deficiencies in recent weapon systems acquisitions. Among the systems identified as having human engineering deficiencies was the F-14 fighter bomber. One conclusion which emerged from the study was that inadequate human engineering in Navy systems acquisitions is a problem that has not been solved (Casey and Sturm, 1974). Incorporation of system safety into acquisitions is another problem which also remains to be solved. It is the authors contention that the failure to properly design human engineering into the systems at the design stage, while partly a by-product

of the acquisition process, is due in great measure to the fact that design personnel are not sufficiently aware of the environment for which they are designing and that insufficient knowledge exists of the operational environment and the complex man-machine interactions of that environment.

One of the more important areas adversely affected by the inadequate human engineering effort has been that of aircraft cockpit design. Daniels(1976), in a study of U. S. Navy aircraft cockpit deficiencies, concluded that there are substantial numbers of man-machine interface problems in naval aircraft cockpits. Schobert(1976), in a follow-up study, concluded that:

> "The cockpit design deficiency structure demonstrated that an identifiable body of common cause factors exists across a large number of different aircraft."

Table I of Schobert's study reveals that 137 respondents to an open question as to the presence of design deficiencies in the aircraft they flew, were able to generate 286 discrepancies distributed over 26 aircraft types. That table is included herein as Table I of this paper. Table II of that same study shows the results of categorization of those cockpit design deficiencies by deficiency type. This table is included as Table II. The most significant aspects of the information contained in those tables are not the numbers involved nor the diversity of the deficiencies. More noteworthy is the information that, (1) All aircraft in the Navy inventory, from the near obsolete to the most modern, have some human factors cockpit deficiencies; and, (2) Since the critical incident technique was used to gather the data, yardsticks established by Flanagan(1962) suggest that the type and variety of

TABLE I - SUBJECT DATA FROM STUDY OF SCHOBERT (1976)

AIRCRAFT TYPE	NUMBER OF SUBJECTS			NUMBER OF INCIDENTS REPORTED			% TOTAL REPORTED
	PILOT	NFO	TOTAL	PILOT	NFO	TOTAL	
ATTACK							
A-4	14	-	14	34	-	34	11.9
RA-5	3	2	5	9	6	15	5.2
A-6	13	2	15	29	3	32	11.2
A-7	7	-	7	20	-	20	7.0
A-3	1	-	1	1	-	1	0.35
Total Attack			42			102	35.65
FIGHTER							
F-4	7	8	15	17	18	35	12.25
F-8	3	-	3	6	-	6	2.1
F-14	2	2	4	3	5	8	2.8
Total Fighter			22			49	17.15
PATROL/ASW							
S-2	10	-	10	12	-	12	4.2
S-3	2	-	2	5	-	5	1.7
P-3	20	1	21	37	3	40	14.0
Total Patrol/ASW			33			57	20.0
AEW							
E-2	8	0	8	18	4	22	7.7
OV-10	2	-	2	3	-	3	1.0
Total AEW			10			25	8.7

TABLE II - DEFICIENCY CATEGORIZATION FROM STUDY OF SCHOBERT(1976)

TABLE II

BREAKDOWN OF INCIDENTS BY MAJOR HEADING AND CATEGORY

		CATEGORY INCIDENTS	HEADING TOTAL	%
I.	EQUIPMENT DESIGN		69	24.13
	A. Control	39		
	B. Display	30		
II.	AIRCRAFT COCKPIT LAYOUT ERRORS		147	51.40
	A. Control and Display Location	60		
	B. Control and Display Geometry	34		
	C. Workspace Area	53		
III.	VISION		23	8.04
	A. Internal	15		
	B. External	8		
IV.	ENVIRONMENT		27	9.44
	A. Environmental Control	13		
	B. Life Support	14		
V.	SAFETY		20	6.99
	A. Inadequate Safety Factors	20		
	TOTALS	286	286	100.00

responses indicate many more deficiences have yet to be identified. Daniels(1976) suggested that every aircraft type acquired gets to the fleet with a number of "less than urgent" human engineering problems, that in many cases the deficiencies last throughout the life span of the aircraft, and that there is a carryover of similar deficiencies between types and generations of aircraft. He states further that

> "The continuation of many of these deficiencies (circuit breaker panels, scan patterns, inability to reach or see) from one generation to the next leads to the conclusion that
>
> a. the Navy does not recognize these deficiencies, or
>
> b. does not consider them important, or
>
> c. has not devised a suitable means of systematically ensuring that new cockpits do not repeat the same deficiencies of older aircraft."
> Daniels(1976)

It is a basic tenet of the Human Factors Engineering discipline that when human engineering design deficiencies are present, the efficiency of the system suffers. The way in which human inefficiency is indicated is through errors and time(delays) (Meister, 1971). Thus, human engineering deficiencies in the design of individual system components or in their interactions with one another, promote both inefficiency and unsafe conditions because the system is predisposed to the operator making an error or being delayed. It follows that the many cockpit deficiencies in

naval aircraft promote errors on the part of the men who fly them and this in turn degrades mission effectiveness and contributes adversely to the overall Naval Aviation accident rate.

Naval Aviators and Naval Flight Officers(NFO's) who fly the Navy's aircraft are often pushed to their absolute physical and mental limits by the demands imposed by today's operating environment. Not only are the aircraft and missions more demanding and complex, but lack of funds often limits flight time (and proficiency) to less than optimal levels. With the addition of fatigue, adverse weather, psychological factors, hectic operations and other unforeseen factors, the man flying the aircraft stands a better chance than ever of becoming overloaded. With challenges such as these facing him, the aviator or NFO can well do without human factors design deficiencies. It is therefore absolutely necessary, both from the standpoint of increasing mission effectiveness and safety of flight, that all present human factors cockpit deficiencies be identified, categorized, and corrected as soon as possible.

A cockpit human factors engineering deficiencies data base, once established, would be invaluable to the Naval Aviation Safety Program. Such a data base could be used for categorizing and ferreting out potential accident inducing factors in individual aircraft types as well as in Naval Aviation as a whole. It would also have application to the area of design, in that data base analyses could be used to establish improved design criteria.

II. BACKGROUND

A. DESIGN ERRORS AND THE HUMAN OPERATOR

Design errors are manifested in improperly designed equipment, in failure to assign effective roles to equipment and personnel, and in failure to meet system requirements (Meister, 1971). This thesis concentrates primarily on the aspect of improperly designed equipment. It must be clearly understood at this point that equipment improperly designed from the human engineering standpoint does, in fact, increase the error potential of the equipment operator. Chapanis(1965) suggested this when he wrote

> "Human factors engineers are the first to grant that people make mistakes. But they raise these important questions also: Is some of the blame to be found in the design of the equipment that people use? Do people make more mistakes with some kinds of equipment or vehicles than others? Is it possible to redesign machines so that human errors are reduced or even eliminated? Research over the past few decades provides us with a resounding 'Yes' to all these questions" Chapanis(1965)

Errors can take many forms and be classified many different ways. Meister(1971) has stated

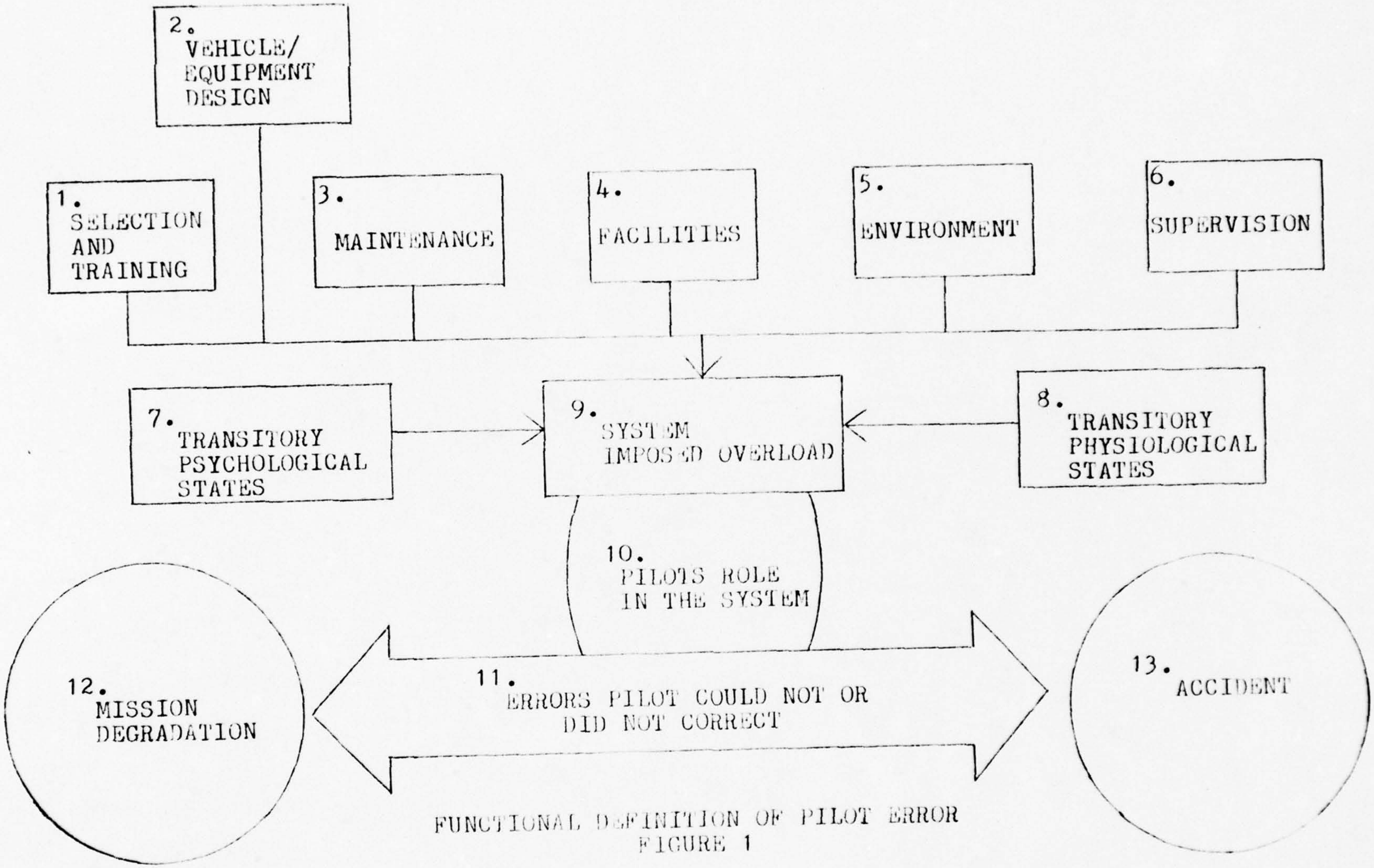
> "The error may reveal itself as

(a) a failure to perform a required action - that is, an error of omission;

(b) the performance of that action in an incorrect manner - that is, an error of commission; or

(c) its performance out of sequence or at an incorrect time."

Of course cockpit design deficiencies promote error just as any other equipment improperly designed for human use, but this type of error is known in aviation circles as "pilot error". Pilot error includes the error types classified above by Meister as well as non-human engineering related error such as that of poor judgement. According to Maxwell and Stucki(1975), pilot error has been considered for many years as the single largest cause of aircraft accidents. Ricketson, Kennamore, and Callen(1975) provide a functional definition of pilot(human) error and its causal elements which clarifies the meaning of the expression. (see Figure 1) Items one through eight identify basic environmental elements which influence the aviation system and are potentially error producing. Item two is given added emphasis in Figure 1 since it represents the focus of this paper. When any of the eight elements, singly or in combination, require attention or response from the pilot beyond his capacity to respond, he enters an overload condition which can culminate in an error. As a result of the overload, varying degrees of performance degradation can be expected.



FUNCTIONAL DEFINITION OF PILOT ERROR
FIGURE 1

B. HUMAN FACTORS AND NAVAL AVIATION

To a large extent technology has outpaced the much needed consideration of human beings in system design. Each generation of sophistication has increased the potential for man's being placed in a position of sensory or mental overload. This applies especially to the field of aviation and specifically to the design of cockpits from which man must control increasingly complex aircraft and associated systems. In particular, it appears that the human aspect of system performance is not being sufficiently considered at the operational level. An Air Line Pilots Association human factors spokesman, after noting that the airline industry suffers severely from the lack of application of the principles of human engineering, stated

> "All aircraft manufacturers I have dealt with have human engineering expertise in their organization. The often compromised effectiveness of the human engineering group in design and manufacture depends to a great extent on individual persuasiveness and corporate philosophy. Once the aircraft leaves the plant, so also are left behind the human engineers. Almost without exception, the companies who operate aircraft and the government authority under which the aircraft is certified and supervised lack human engineering expertise. The number of the changes an aircraft undergoes in retrofitted equipment, revised procedures and new operating conditions all take place without the benefit of trained human factors personnel." Stone (1975)

The author considers the above to also be true for Naval Aviation but to a much greater extent. There are very few human factors specialists in the Navy today and virtually none of these personnel are engaged in work in the operational arena. The typical Naval Aviator's operational environment is one of the more demanding in the Navy today. Not only does he fly complex, high performance aircraft but he does so on varied missions and under all types of weather

conditions. Equipment that may not have been particularly well designed in the first place is retrofitted, additional missions are assigned to aircraft, procedures change, and operating conditions vary, just as is cited above by Stone, and this also without the benefit of inputs from trained human factors personnel.

Naval Aviation, in the absense of trained human factors engineering personnel who fully understood the operational environment, has not in the past had a program for identifying and eliminating or decreasing the effects of human factors cockpit deficiencies. Although reports of design deficiencies submitted by fleet units have been the basis for past cockpit modifications, all too often the deficiencies are accepted as an unchangeable fact of life and ways are found to circumvent the problem. A major problem in identifying deficiencies is the fact that often consensus cannot be reached on the degree of severity of a particular problem by the men who fly the aircraft.

The Navy has had for many years an aircraft accident and serious incident reporting procedure which has had very limited success in identifying cockpit human factors deficiencies. This procedure is promulgated by OPNAVINST 3750.6(series). Under the procedure all aircraft accidents and serious incidents involving naval aircraft are to be reported with investigative comments to the Naval Safety Center within specified time limits. The accident reporting procedures are basically sound, are of no consequence to this paper, and will not be discussed further. This is not so for incident reporting. Far more incidents and near-accidents occur than accidents and unless the circumstances surrounding and causing them are identified and corrected, there is a very good chance of their diasterous reoccurrance. In theory, when an aviator has an accident, near accident, makes a serious error, or in

general gets himself into a precarious situation either because of human error, equipment malfunction, or material failure, the facts are reported to the Naval Safety Center for inclusion in their master data bank. In practice, material failures and equipment malfunctions make up the majority of the incident reports. There are a number of reasons for this, the foremost being:

1. The Naval Aviator and NFO are very proud and competitive individuals who dislike admitting errors. When errors are made the tendency is to be close mouthed about it and try not to let it happen again.

2. There is keen competition among these men to remain promotable within the Navy rank structure. Admission of an error could lead to to an adverse evaluation or even punishment.

3. The aviators and NFO's are well aware that all incident reports eventually find their way into the Naval Safety Center's computer. They realize that mistakes made by them for any reason will follow them throughout their careers, because their complete file is available at any time to their Commanding Officer.

The fact that many, perhaps even a majority, of the errors made by these individuals could be directly or indirectly linked to human factors deficiencies or other non-judgement sources, has little bearing on the fact that these men perceive the act of reporting an error as a threat to themselves. For the above reasons it is suspected that the Naval Safety Center's data bank is not representative of the real world but, more important, the Naval Safety Center has lost credibility and with that credibility, a means of identifying problems before they spawn accidents.

C. DATA COLLECTION TECHNIQUES

There are a number of available techniques for gathering the required cockpit human factors deficiency data base. Most have been used at one time or another in the past to gather human factors data in the aviation community. All have their advantages and disadvantages and many will be discussed herein.

The means of collecting the data can best be broken into two general areas; (1) that which uses as the data source the actual personnel who fly the aircraft, and, (2) that which uses other sources such as the Naval Air Developement Center Human Factors Branch personnel, computer simulations, a traveling team of human factors experts who could visit various Naval Air Stations in search of hard data, and other such "non-human operator" related collection methods. Atkins(1969) worked in the operational arena in gathering data for a study of U. S. Air Force aircrew work station geometry. He concluded, after collecting data from a broad range of sources, that none was as comprehensive, easy to get and as valuable as aircrew generated data obtained in an operational environment. The author concurred with that evaluation and will henceforth in this study be concerned only with those data gathering techniques using aircrew personnel as the data source. Techniques considered were the at-source, group orientation, and command methods originally presented by Vasilas et al(1953); the critical incident technique(Flanagan, 1963), and questionnaire methods(Oppenheim, 1966).

Vasilas et al(1953) focused their study on developement of procedures for gathering U. S. Air Force near-accident

data. Three methods - at-source, group orientation, and command - were studied. In the first method, individual report blanks were made available for reporting hazardous incidents after flight. Forms were placed in many convenient locations and aircrew personnel were instructed to report any incidents they experienced or observed. Completed reports were to be sealed in an envelope and dropped in a collection box.

In the group orientation method, an interviewer instructed groups of 10 airmen at a time on the nature of the procedure and the value of collecting such incidents. He then had the men write descriptions of whatever incidents they could recall and seal them in an envelope prior to collection. The command method for collecting data was a system in operation at several air bases. Subordinate units were required to maintain weekly activity reports which included reports of near-accidents.

Analysis of the results of the study showed nearly two and one-half times as many incidents were obtained with the group orientation method as opposed to the at-source method. It was thought that this was due mainly to peer pressure to conform and the increased awareness of the need for collection of the incident reports brought about by the presence of the interviewer.

Over seventeen times as many incidents were collected by the group orientation method as were collected by the command method. Chapanis(1959) made the following observations regarding that aspect of the study:

> "Most of the incidents reported in the command method were incidents which were certainly observed by someone else.
>
> Most interesting, however, was the distribution of types of items. In the command method, most of the reported incidents fell into the category of mechanical malfunction. In the group orientation method most of

the reported incidents fell in the category of personal errors.

A reasonable interpretation of these results is that the crew members hesitate to report incidents under the command method because they are afraid the incidents will be used to evaluate or punish them." (Chapanis, 1959)

The critical incident technique is yet another viable means of gathering data such as that required for the cockpit deficiencies data base. The critical incident technique was originated by Flanagan(1962) and involves asking, "Tell me about some mistake or error you have made in operating this equipment", of the operator of a particular equipment. The basic assumption underlying the method is that from a large number of personnel one can determine most of the difficulties(errors) which lead to critical situations for any particular man-machine system. Daniels(1976) successfully used the critical incident technique in a group orientation setting to establish the existence of the Naval Aviator and Naval Flight Officer as a previously untapped and valuable source of human factors cockpit deficiency data. The data provided in Tables I and II was gathered using that technique.

Questionnaires have the advantage of being very versatile and have proven ability to gather virtually any type of data. Oppenheim(1966) discusses at length the advantages and disadvantages of the many types of questionnaires and questionnaire techniques.

There are undoubtedly many variations and combinations of the above techniques as well as other less known techniques which would be applicable to the cockpit deficiency collection effort. However, the techniques considered above are the more accepted of those available and for that reason were the only ones considered for the data collection vehicle.

D. COLLECTION TECHNIQUE REQUIREMENTS

Any successful effort to gather the required comprehensive human factors cockpit deficiencies data base must first overcome a number of problems, some of which are unique to the operational environment from which the data will come and some of which are common to any comprehensive data gathering effort. The data source itself involves thousands of aviators and NFO's who man the cockpits of dozens of different aircraft types. The aircraft squadrons to which these men are assigned have many different missions and are scattered widely in location through the United States and the world. Keeping those factors in mind, it would therefore be desirable that the data collection vehicle possess the following attributes:

1. Be applicable to aircraft types ranging from helicopters to fighter-bombers and to men whose missions vary from highly demanding to exceedingly routine.

2. Be relatively easy and cost effective to administer, collect, and analyse.

3. Be efficient from the standpoint of taking as little time as possible to complete, since time is a particularly valuable asset of fleet aviators and NFO's.

4. Be capable of eliciting data to the depth and detail required.

5. Be capable of eliciting from the men involved their true thoughts and opinions by removing any threat of evaluation or punishment. If you want to collect a

maximum amount of data involving human error you have to divorce the threat of punishment or evaluation from the reporting (Chapanis, 1959).

6. Be structured such that fleet aviators and NFO's will find responding to be an interesting learning experience as well as a duty.

7. Have incorporated into it a system which will permit the respondent to quantify, (1) the degree to which he perceives a particular deficiency to be a physically or mentally difficult problem, and, (2) the degree to which he perceives a particular deficiency to be a safety hazard. Such a system would allow relative comparisons of deficiency severity within type aircraft, given sufficient data.

E. COLLECTION TECHNIQUE SELECTION

Available techniques for data collection were considered, the foregoing requirements being used as the basis for selection of the collection vehicle. Candidates were the group orientation, personal interview, critical incident and questionnaire techniques. The decision was made to use a combination of the group orientation, critical incident and questionnaire techniques as the best course of action considering the requirements of this particular situation.

The choice of the combination of techniques was made on the premise that the data could best be collected with a comprehensive questionnaire composed of many detailed, open ended questions, each requiring short answers. This questionnaire would include a quantification scheme for measuring relative magnitudes of deficiency severity and criticality. In a sense each question could be considered a separate application of the critical incident technique. If employed on a fleet-wide basis, the questionnaires could be forwarded in quantity to Navy aircraft squadrons where the squadron Safety Officer would conduct the briefing of the respondents in accordance with procedures of the group orientation method. The questionnaires would then be distributed to each individual, to be sealed upon completion by the individual and mailed individually, or completed sealed and returned to the Safety Officer for mailing to the collection center.

The following advantages appear to accrue from using the comprehensive questionnaire described above as a data gathering vehicle:

1. A questionnaire can readily be tailored to the needs of the researcher and include open or closed questions. The author surmised that, because of the diverse nature of the aircraft cockpits and missions, the use of closed questions was not feasible. Too many questions, or else many different questionnaires would have been required. However, detailed open questions, probing the many and varied aspects of control, display, and general workspace design, were feasible and particularly applicable to the diverse range of data available.

2. The cost of using mailed questionnaires is far more reasonable than other data gathering means available.

3. If constructed properly, the questionnaire would solicit short answers to the open questions which could then easily be categorized. This would promote efficiency from the respondents point of view as well as the analyst.

4. Use of a questionnaire with detailed open questions would allow quantification by the respondent of severity and criticality of specific and general deficiencies. This quantification, when averaged over enough responses, would provide a number which would allow rankings of cockpit deficiencies for each aircraft in terms of degree of severity.

5. The questionnaire which can be completed at the respondents leisure in privacy can most readily promote the important idea of anonymity.

6. By providing detailed questions, incidents which may not have been recalled using the critical incident

technique, stand a much better chance of being recalled. Detailed questions could also be used to educate the aviator or NFO in the basic principles of human factors engineering as a side effect of responding to the questions.

III. METHOD

A. QUESTIONNAIRE DEVELOPEMENT

The questionnaire was designed around general principles established by Oppenheim(1966). It was envisioned that the final product would be a comprehensive, open question questionnaire with sufficient questions of great enough detail to include all relevant aspects of human factors engineering in cockpit design. However, it is noted that because of the diversity of aircraft types, the fact that Naval Aviators and NFO's are involved, and the subjective nature of the perceived deficiencies, the questions could not be made detailed enough to result in across the board short answers. That, and the fact that the questionnaire was necessarily lengthy in order to cover the broad application of human factors in cockpit design, are preliminarily recognized as disadvantages.

The process of formalizing the questionnaire was a lengthy one involving decisions as to the content of the many individual questions, the content of the questionnaire introduction and instructions, the types of personal data to request from the respondent, the type of deficiency severity quantification scheme to employ, and many other important factors such as questionnaire format, etc. The overall questionnaire design employed Oppenheim's principles as well as the data collection requirements discussed previously.

Questions were grouped within the questionnaire into

four major categories of Controls and Primarily Tactile Functions, Displays and Primarily Visual Functions, Psychological Factors, and Miscellaneous Factors. A short introduction was provided for each category.

The introduction to the questionnaire was designed so as to acquaint the respondent with human factors engineering concepts and generally put him at ease. The prelude to the questions themselves required a short description of the concept of system safety and human factors engineering, an explanation of the purpose of the survey and its general contents, definitions of key terms such as "control" and "display", instructions for completing the questionnaire and a statement of the anonymity of the sources of specific data. (See Appendix A which comprises the finished questionnaire.)

In order to have a means of quantifying the amount of physical or mental difficulty a particular deficiency presents to the operator, a severity scale was conceived. A criticality scale was also conceived, this scale being a means by which the operator quantifies his perception of the deficiency's hazard to safe flight. Both scales range from one to five with five representing the highest severity or criticality. Table III, which appears also in the questionnaire, explains the ratings more thoroughly. It is hypothesized that these quantifications of deficiency severity and criticality, when averaged over a moderate number of responses for a particular deficiency, will provide a viable measure of severity and criticality. This will permit the ranking of deficiencies for a particular cockpit in terms of their perceived contributions to inefficient and/or unsafe operations.

An initial data section at the beginning of the questions comprises the only personal data required of the

SEVERITY AND CRITICALITY RATING SHEET

You are asked to rate deficiency severity and criticality numerous times within this questionnaire. The scale ranges from 1 to 5 with the higher numbers indicating increased severity and criticality. In order to provide clarification of the meaning of each rating the following interpretation is provided:

SEVERITY-The difficulty the named deficiency presents to the operator.

Rating	Reaching, seeing, interpreting, etc., this control or display or performing this act, in my opinion,
1	is not at all difficult or only slightly so
2	is somewhat difficult
3	is quite difficult
4	is extremely difficult
5	is impossible or nearly so

CRITICALITY-The potential of the named deficiency for causing an accident or serious incident.

Rating	Reaching, seeing, interpreting, etc., this control or display or performing this act, in my opinion,
1	has virtually no effect on flight safety
2	has some potential for causing an accident or serious incident
3	has considerable potential for causing an accident or serious incident
4	has great potential for causing an accident or serious incident
5	either already has caused an accident or serious incident or will cause one in the near future

Table III - Severity and Criticality Rating Sheet

respondents. Requested is the date, the squadron to which the individual is assigned, whether the respondent is a pilot or NFO, the aircraft the respondent currently flies and is critiqing, the hours flown in that aircraft and the total hours flown. This data will allow analyses as to differences in perceived deficiency severity and criticality among pilots and NFO's of different experience levels.

The questionnaire content, with respect to individual question composition, was drawn from a variety of sources, including the authors' experience, MIL-STD-1472, MIL-STD-882, the work done by Schobert(1976) in categorizing deficiencies, and the actual critical incident technique data collected by Daniels(1976).

The questionnaire was printed in double-spaced format on one side of the paper only, for ease of reading as well as ease of refering to previous pages while completing the questionnaire. It was considered that these advantages as well as comments made in the introduction, would overcome the negative psychological aspect associated with a moderately lengthy questionnaire.

B. DATA COLLECTION

The completed questionnaire was administered to twenty-one Naval Aviators and four Naval Flight Officers in attendance at a six-week Aviation Safety Officer course at the U. S. Naval Aviation Safety School, Naval Postgraduate School, Monterey, California. This population serves excellently as a test group for verifying the applicability, reliability and validity of the questions contained in the questionnaire, in that the men involved are for the most part currently proficient in an operational aircraft, and are assigned to many different types of aircraft. It would be feasible for the author to collect a large quantity of data on a specific type aircraft. However, it is preferable at this point to instead concentrate on ensuring that the questionaire content is broad enough and yet specific enough to apply to all naval aircraft. The respondents were given one week to complete the questionnaire.

IV. RESULTS

Table IV summarizes the numerical data obtained from the twenty-five completed questionnaires. For each question the total number of responses to that question, total number of different aircraft types cited, and breakdown of severity and criticality ratings, by responses per rating, are given. For example, question number one obtained forty-one responses distributed over eight different types of aircraft. With regards to criticality, six of the deficiencies identified via question one were judged as having great potential for causing an accident or serious incident(assigned a rating of 4), and two were considered to have either already caused an accident or serious incident or would cause one in the near future(assigned a rating of 5). The asterisked columns in the table identify the number of responses for which no rating was assigned. The final page of Table IV provides a percentage breakdown of the severity and criticality assignments overall. In all, 539 human factors cockpit deficiencies were identified by 25 respondents. The 539 deficiencies were distributed over 15 different aircraft types.

The variety of responses and the detail which many of the respondents provided made summarization of the complete data nearly impossible. Therefore Tables V and VI are provided as examples of the varied responses obtained. Table V comprises the responses to question thirty-one while Table VI comprises the responses to question ten.

TABLE IV - QUESTIONNAIRE RESPONSE SUMMARY

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
1	41	0	3	14	10	6	8	0	6	16	11	6	2	8
2	16	1	6	5	4	0	0	0	1	6	6	1	2	8
3	4	0	3	1	0	0	0	0	1	2	0	0	1	3
4	3	0	1	2	0	0	0	0	0	3	0	0	0	3
5	6	0	2	2	2	0	0	0	2	3	1	0	0	4
6	16	0	0	9	5	2	0	0	2	7	5	2	0	9
7	5	1	0	3	0	1	0	1	2	2	0	0	0	4
8	35	1	0	1	1	0	0	1	1	1	0	0	0	3
9	4	0	0	0	4	0	0	0	1	1	1	1	0	4

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
10	7	0	1	1	2	2	1	0	0	2	1	2	2	6
11	9	0	1	3	5	0	0	1	3	4	0	0	1	5
12	20	0	0	6	6	6	2	0	7	7	5	0	1	8
13	3	0	0	1	2	0	0	0	1	2	0	0	0	1
14	13	0	0	1	0	1	11	0	1	6	0	4	2	6
15	8	0	1	4	2	1	0	1	1	6	0	0	0	6
16	11	1	0	7	3	0	0	1	2	6	2	0	0	5
17	2	0	1	1	0	0	0	0	1	0	1	0	0	3
18	8	0	0	5	2	0	1	0	0	5	2	1	0	8
19	24	2	7	12	2	0	1	2	4	7	3	6	2	9

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE *	1	2	3	4	5	NUMBER RESPONSES PER CRITICALITY CODE *	1	2	3	4	5	AIRCRAFT CITED
20	13	2	3	1	1	2	4	2	5	1	2	2	1	6
21	5	0	1	0	2	0	2	0	1	3	0	0	1	6
22	3	0	0	1	2	0	0	1	1	1	0	0	0	3
23	4	0	1	1	0	2	0	0	3	1	0	0	0	3
24	3	0	2	1	0	0	0	0	2	1	0	0	0	3
25	2	0	1	1	0	0	0	0	1	0	1	0	0	2
26	4	0	1	1	2	0	0	0	2	0	2	0	0	4
27	24	1	15	5	3	0	0	1	4	4	9	4	2	8
28	6	1	1	3	1	0	0	1	0	2	1	1	1	5
29	10	0	3	4	3	0	0	0	1	5	2	1	1	6

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
30	10	1	2	5	2	0	0	1	0	6	2	1	0	6
31	16	2	2	7	4	1	0	1	1	10	4	0	0	9
32	15	1	2	8	2	2	0	2	2	7	3	1	0	9
33	5	1	0	2	1	1	0	1	0	0	0	3	1	2
34	0													
35	9	4	1	4	0	0	0	3	1	2	3	0	0	7
36	0													
37	15	0	0	8	5	1	1	1	6	6	1	1	0	7
38	4	0	0	2	2	0	0	0	1	2	1	0	0	2
39	7	0	1	4	2	0	0	0	1	1	3	0	2	5

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
40	19	2	1	5	5	4	2	2	5	5	5	2	0	9
41	1	1	0	0	0	0	0	1	0	0	0	0	0	1
42	5	1	1	3	0	0	0	1	0	3	1	0	0	6
43	13	3	0	4	4	2	0	3	1	5	3	0	1	11
44	7	1	0	4	1	0	1	1	3	2	1	0	0	4
45	16	0	1	6	4	3	2	0	6	8	1	1	0	6
46	7	0	0	4	3	0	0	0	0	5	1	1	0	5
47	5	0	0	3	2	0	0	0	0	4	1	0	0	5
48	1	0	0	0	1	0	0	0	0	0	0	1	0	1
49	2	C	0	0	1	1	0	0	0	1	0	1	0	1

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPONSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
50	0													
51	5	0	0	1	3	1	0	0	1	1	2	1	0	5
52	2	0	0	3	1	0	0	0	0	4	0	0	0	3
53	1	0	1	0	0	0	0	0	1	0	0	0	0	1
54	18	0	0	9	5	2	2	0	0	8	8	1	1	10
55	24	0	1	9	5	6	3	0	5	5	3	8	3	8
56	3	0	0	0	1	2	0	0	0	2	1	0	0	3
57	2	0	0	0	0	1	1	0	0	1	1	0	0	3
58	3	1	0	0	0	1	1	1	0	0	1	0	1	3
59	7	3	0	0	0	2	2	3	0	0	1	0	3	2

TABLE IV - CONTINUED

QUESTION NUMBER	TOTAL RESPCNSES	NUMBER RESPONSES PER SEVERITY CODE						NUMBER RESPONSES PER CRITICALITY CODE						AIRCRAFT CITED
		*	1	2	3	4	5	*	1	2	3	4	5	
60	14	3	1	1	5	2	2	3	1	6	2	2	0	8
61	4	0	1	1	1	0	1	0	1	1	1	1	0	4
62	4	2	1	0	1	0	0	2	2	0	0	0	0	7
63	1	0	1	0	0	0	0	0	1	0	0	0	0	1
64	N/A													
65	15	1	2	4	2	4	2	1	3	7	2	1	1	9
66	N/A													
TOTALS	539	37	73	193	127	59	50	39	98	206	107	57	32	
PERCENTAGE TOTALS		7%	14%	35%	24%	11%	9%	7%	18%	38%	20%	11%	6%	

TABLE V - RESPONSES TO QUESTION THIRTY-ONE

QUESTION: During critical phases of flight such as take-off, low altitude manuevers, multiple aircraft rendezvous', approaches, and landings, are you ever bothered by distractions from inside the cockpit such as noises, lights, etc.?

RESPONDENT	AIRCRAFT	SEVERITY/ CRITICALITY	RESPONSE
NFO	A-6E	-/3	FLASHING BREAKAWAY LIGHTS IN PILOT[S OPTICAL SIGHT - Caused by weapons computer malfunction. Especially hazardous during a night carrier approach.
PILOT	F-14A	2/2	GLOVE VANE POSITION LIGHTS- Extremely bright. Come on when putting gear and flaps down for approach. Very distracting and vertigo inducing in IFR conditions.
PILOT	P-3A	2/2	COCKPIT LIGHTING - The location of the floodlight used to illuminate the pilots approach plate is such that the pilots head interferes and casts a shadow.
PILOT	S-3A	3/3	ACLS ADVISORY LIGHTS - ACLS lights cannot be dimmed.
PILOT	S-3A	-/-	NIGHT FORMATION FLIGHT- The S-3 canopy is very large and the cockpit lighting is reflected back towards the pilot. Very distracting for night formation flying.
PILOT	S-3A	3/3	ACLS ADVISORY LIGHTS - No rheostat for the ACLS advisory lights. They are very distracting on night approaches.

TABLE V - CONTINUED

RESPONDENT	AIRCRAFT	SEVERITY/ CRITICALITY	RESPONSE
PILOT	S-3A	2/2	MAD READY LIGHT - No rheostat. Is a real bother at night in the MAD pattern.
PILOT	A-4/TA-4	2/2	LAWS AURAL TONE - No volume control on the Low Altitude Warning System aural tone. On low level routes tone is super loud.
PILOT	A-4/TA-4	2/2	IFF CAUTION LIGHT - Frequently comes on in flight and is particularly distracting because it is red and fairly close to the fire warning light.
PILOT	F-4J	3/3	WINDSHIELD DEFOG - I find it very uncomfortable on descent and approach to have hot air blasting in my face so I don't always use it although required to.
PILOT	A-7E	2/2	MASTER FUNCTION SWITCHES When selected at night the yellow lights are too bright and cause considerable annoyance.
PILOT	A-7E	2/2	OXYGEN LIGHT/MASTER CAUTION -On 75% of all catapault shots the oxygen light will come on and cause the Master Caution Light to flash. This is an inopportune time to have to look down at the Master Caution Panel.
PILOT	S-3A	4/2	ACLS LIGHTS - Way too bright. No brightness control. When we are planning on flying night approaches we take masking tape to put over these lights and that doesn't help too much.
PILOT	A-4/TA-4	1/2	IFF LIGHT ON GLARE SHIELD - Distracting in almost any phase of flight. It's near the FIRE light.

TABLE VI - RESPONSES TO QUESTION TEN

QUESTION - Think specifically of emergency procedures. Do any of these require manipulations of switches and controls or sequencing of actions which, in your opinion, are too complex and time consuming?

RESPONDENT	AIRCRAFT	SEVERITY/ CRITICALITY	RESPONSE
PILOT	F-14A	3/3	TRIM PROCEDURE - Emergency procedure in case of split flaps/slats or stuck spoiler(in flight) requires attempting to counter an uncommanded roll with opposite lateral stick while trimming in the opposite direction to provide maximum opposite spoiler deflection. The movement of the stick and trimming are done simultaneously in opposite directions with the same hand.
NFO	RF-4B	3/2	RADAR SCOPE - Radar scope is a distracting nuisance to the pilot.
PILOT	P-3A	3/3	EGRESS FROM PILOT'S SEAT - If a pilot were ever required to bail out of a P3 he would most likely not make it.
NFO	RF-4B	5/4	CIRCUIT BREAKERS - Controlling circuit breakers in emergency procedures for this aircraft is a procedure that is hopelessly complex.
PILOT	S-3A	3/2	AIR START PROCEDURE - There are 10 separate items on the memory checklist.

TABLE VI - CONTINUED

RESPONDENT	AIRCRAFT	SEVERITY/ CRITICALITY	RESPONSE
PILOT	S-2A	4/2	WING FIRE - Requires location of several different circuit breakers on the overhead panel.
PILOT	S-2A	2/5	EMERGENCY LANDING GEAR EXTENSION - Takes too much time, effort and attention from the pilot if he has to do it himself and will severely distract the co-pilot. This has caused previous fatal accidents.
PILOT	A-7A	1/4	EMERGENCY LANDING GEAR EXTENSION - Requires using left hand(normally on throttle) to pull handle and hold it out while the gear slowly extend. As gear extend, drag increases causing aircraft to slow. Power is added by reaching across body with right hand thus taking right hand from stick. This is a very unsafe and uncomfortable procedure.
PILOT	A-7A/B/C	4/5	EMERGENCY POWER PACKAGE - Unless cat shot taken with this deployed(debatable) the reaction/action/run-up time would be too long. You cannot get to the EPP fast enough because of its poor location in the cockpit.

V. CONCLUSIONS

In all, five hundred and thirty-nine human factors cockpit deficiencies were identified by twenty-five respondents to the Cockpit Deficiency Questionnaire. This factor alone provides ample justification for placing additional emphasis on this technique for gathering the required human factors cockpit deficiency data. The approximately twenty-two responses per respondent compares very favorably with the average two responses per respondent obtained by Daniels(1976) and Schobert(1976). The data contained in Tables V and VI evidences the wide variety of existing cockpit deficiencies and the range of severity and critality ratings of those deficiencies.

While the Cockpit Deficiencies Questionnaire was very successful in gathering varied data, there was an insufficient number of respondents reporting on any one specific aircraft cockpit to permit analysis of a specific cockpit. The numbers of respondents for a given type aircraft varied from five S-3A pilots to one A-6E NFO and one F-14A pilot. Therefore, the comments and conclusions made herein are at best tentative and serve only to identify trends and probable areas for concern on the part of safety specialists and design engineers. Further application of this data collection technique to large groups of operators will provide the material needed for in-depth analyses.

Subjective analysis of the data from the twenty-five completed questionnaires leads the author to the following tentative conclusions as an example of the types of existing

cockpit deficiencies which can be identified with the questionnaire technique.

1. Design personnel have not in the past taken into account the fact that aviators and NFO's must at times wear heavy, bulky, restrictive clothing such as wet suits and winter survival equipment. When this type of equipment is worn in most of today's aircraft the operators capability for reaching required controls is degraded significantly. This problem and the related one of fatigue associated with wearing a wet suit for long periods of time, extends across many types of aircraft.

2. Circuit breaker location and accessability appears to be a problem in many aircraft. As an example, F-14A front cockpit circuit breakers are unlighted and difficult to reach and could be the primary causal factor of an accident should there arise a requirement for the pilot to pull or reset one at night in an extremis situation.

3. The S-3A aircraft appears to have a number of human factors deficiencies designed into its cockpit. Among the many deficiencies cited by the five S-3A pilots are the following:

(a) The flap switch is actuated by reaching over and behind the throttles. This control is detented such that when a flap movement is required the pilot must devote his full visual attention to the task.

(b) The launch bar switch is easily inadvertently actuated. A lowered launch bar will cause damage if it is down during an arrested landing.

(c) The ACLS (Automatic Carrier Landing System) advisory lights are very bright and cannot be dimmed. The ACLS is primarily of value in night, IFR conditions and thus, in order to use the ACLS, one must accept the distractions at a time when they are least needed. This problem is identified in Table VI.

(d) The fire warning system is easily confused. There are two warning lights, one in front of each pilot, which warn of a fire in either of the two engines. When the pilot sees the fire warning light he is to immediately look to the "fire pull handles". Lights in the "pull handles" identify the engine which is on fire. He is then to place the appropriate throttle off, pull the correct pull handle, and secure the correct ignition. Apparently a number of experienced aviators have mistakenly secured the left(good) engine when given a right engine failure in the S-3 simulator. It appears likely that the fact that the pilot observes the left hand light more clearly than the right hand light, predisposes him to identifying the left engine as the problem.

4. Personal equipment and navigation publication stowage constitutes a real problem in many aircraft cockpits from the P-3A to the F-14A.

5. Ejection seat discomfort and related fatigue factors are a major source of contention among aviators and NFO's. In addition, it appears that the primary(upper) firing handle on most Navy ejection seats is unusable to a large segment of the operators. Nearly fifty percent of the deficiencies noted in question fifty-five were related to ejection seat problems and received ratings of four or five in criticality. See Table III.

6. There appears to be a problem across most aircraft with warning signals such as fire warning lights. Question fifty-four, which queried respondents as to the adequecy of the signals, received eighteen responses across ten aircraft types.

In addition to providing cockpit deficiency data, the twenty-five completed questionnaires yielded information pertaining to the quality and applicability of the

questions. Again the small number of respondents for each type aircraft limited the author's ability to make firm conclusions. The following tentative conclusions are made:

1. The majority of the respondents considered the time spent completing the questionnaire to have been very worthwhile. Negative reaction to the length of the questionnaire was minimal.

2. Questions 20, 21, and 22 appear to have significant overlap as presently written and could be combined into one question.

3. Question 1 should be moved into the interior of the questionnaire as its generality and position as the first question answered, prompted many responses which better fit other questions. A more specific question should be chosen for the lead-off question.

4. Thought should be given to combining questions 19 and 39 in as much as the respondents were unable to clearly differentiate between the two situations.

5. Questions 4, 8, 13, 17, 22, 24, 25, 34, 36, 41, 48, 49, 50, 53, 56, 57, 58, and 63 received three or less responses each and should be reviewed with respect to the rewording or combining of questions.

On the basis of the 539 deficiencies identified and rated for severity and criticality, the quantification technique appeared to be valid. Additional data must be collected and analysed before the technique can be fully validated, however, the overall response summarization provided in Table IV shows that the responses tend to be approximately normal for both severity and criticality ratings. In both cases the distribution is skewed slightly left with the modal response being a two.

The only major questionnaire technique disadvantage noted by the author was the fact that the responses are

descriptive and, although the majority are short, there is nevertheless a requirement to read and analyse each comment to determine the precise nature of the deficiency. This is time consuming and inefficient and will ultimately impact substantially on the cost of the data collection program. However, the subjectivity and variability of the data is a reflection of the variability of the human operators involved and is the very thing which makes the data valuable and worthwhile.

VI. RECOMMENDATIONS

The Cockpit Deficiencies Questionnaire should be validated further as soon as possible by being administered to approximately one-hundred pilots and NFO's from each of two aircraft communities. Preferably a single-seat and a pilot/NFO manned aircraft would be chosen.

Once the questionnaire has been adequately validated it should be administered Navy-wide to a sufficient number of aviators and NFO's from each type aircraft to allow establishment of the human factors cockpit deficiency data base. Having established the data base, a comprehensive effort can be made to identify deficiencies which exist across different aircraft types. The resulting analysis should be directed towards improving and updating present design criteria.

Concurrent with the effort to provide better design criteria should be an effort to identify, categorize, and correct the most critical deficiencies existing in today's aircraft. The information being gathered on each specific aircraft for inclusion in the data base can be analysed separately with the goal of ranking deficiencies in terms of deficiency severity and criticality. Such an analysis will allow establishment of priorities in the program to correct or lessen the effect of existing deficiencies.

APPENDIX A

COCKPIT DEFICIENCIES QUESTIONNAIRE

INTRODUCTION

This questionnaire involves System Safety/Human Factors Engineering(SS/HFE) and its relationship to you, the pilot or NFO assigned a seat in one of the dozens of aircraft types in the Navy inventory. The results of this survey will affect Naval Aviation Safety as well as future aircraft design.

System Safety/Human Factors Engineering can most simply be described as "the process of designing for safe and efficient human use". The objective of SS/HFE as it relates to cockpit design is to provide you, the human operator, with a cockpit which is designed with the full range of your capabilities and limitations in mind. Cockpits should be adapted to your limitations; you should not be the one who does all the adapting. Please note that the word cockpit as used herein refers to the entire cockpit layout including seats, control system and other controls, displays, environmental system, etc.

There are certainly many good and bad designs for each item in a cockpit and SS/HFE strives to incorporate the good while eliminating the bad. Unfortunately, System Safety and Human Factors Engineers were non-existent when some of the aircraft we fly were designed and, for various reasons, the

latest SS/HFE technology and knowledge has not been fully integrated into the more modern aircraft. Thus, the cockpit in which you presently get your flight time may have benefited to varying degrees from SS/HFE expertise.

As noted above there are good and bad designs. But how is the good to be differentiated from the bad? In the old days if man could function at all in a cockpit, the design was considered a success. We have come a long way since then but while a great deal of research is being done in cockpit design, the effort continues to be hindered substantially by the lack of complete understanding of how the human mind functions in recognizing, processing and responding to stimuli. In the abscence of concrete information a major (and costly) source of data with respect to good versus bad design turns out to be the aircraft accident report. If a particular display or control can be directly related to an accident it has a good chance of being identified as a problem. At worst the problem will be recognized and additional training and emphasis will be devoted to countering(adapting to) the hazard.

But what about the problems which are not so obvious? How about the "pilot error" accidents which never really get to the heart of the matter? What of the many incidents or near accidents which go unreported because of our inclination to feel that no matter how well or poorly designed a system is, we should be able to master it just the same. The fact is that you and all of your contemporaries are limited in your capacity to perform by many factors, the most significant of which involve the functioning of the human brain. Absolute limits exist in the amount of information you can process at any one time, reaction times,etc. Deficiencies in the design of the controls and displays located around you in the cockpit can slightly slow your actions, overload your ability to process

sensory inputs, confuse you when you don't need to be confused, and in general cause you not to be at your best. The purpose of this survey is to identify the major deficiencies which exist in the current inventory aircraft as seen by the men who fly them. Unbelievably, this has not been done before on this scale. The resulting data will be an invaluable aid in identifying current safety problems and will provide the basis for improved design criteria.

INSTRUCTIONS

The questions in this survey have been grouped into four main categories according to the general subject of the question. Each section is preceded by a brief description of the subject matter included in that section. The four sections are:

1. Controls and Primarily Tactile Functions

2. Human Behavior (Includes conditioning and transfer of training)

3. Displays and Primarily Visual Functions

4. Miscellaneous (Includes environment, NFO/co-pilot station lighting, etc.)

Most of the questions involve your identifying specific components which you consider deficient within a particular context. In addition to identifying that component, you are asked to assign a number from 1 to 5 which you feel best describes the degree of severity of the deficiency(to what extent is it a physical or mental problem to you) and the criticality of the deficiency (to what extent does it constitute a safety hazard). In both cases the number 1

represents the lowest extent and the number 5 the highest. At this time you should detach the very last page from the survey, as that page provides further guidance with respect to the meaning you should attach to each code. Keep that page handy for reference while filling out the survey.

The questionnaire was designed so as to require of you a minimum amount of writing and as small an investment of your time as possible. The disadvantage of this, however, is that it restricts you from fully expressing your opinions in cases where the questionnaire doesn't include enough options or doesn't cover a particular area. Please feel free to write notes in the margins or expound at length on the reverse side of a page. All comments will be read and taken into account in evaluating your response.

You will undoubtedly encounter some redundancy in the questions and you will undoubtedly find yourself identifying the same component as a problem in two or more contexts. That is to be expected. Each question is significantly different in regards to its purpose in the overall data gathering effort.

Comment only on the aircraft you are now flying or flying in. Also comment only on the seat you occupy unless instructed differently. If you are flying two or more types of aircraft concurrently, select the one with which you are most familiar. If you feel very strongly about a deficiency in another aircraft feel free to include that information but please denote those entries with an asterisk(*) in the left margin.

NFO's -- Deficiencies in the controls and displays you operate and monitor will impinge heavily on mission effectiveness and directly or indirectly affect safety of flight. But if you are in a side by side cockpit arrangement

you have a need to monitor the pilot's instruments and share some functions with him. You therefore should identify any problems with items that are on his side of the cockpit but which you also operate and monitor on a shared basis. However, identify also all controls and displays for which you alone are responsible . The intent of the survey is to identify all control and display problems, not just the ones the pilot has.

Work independently on the survey. Please don't attempt to rally the rest of the squadron around your point of view. If a particular item is a problem it will be identified by a sufficient number of individuals to stand out in the final analysis.

Try to take into account when thinking about each particular question that we as individuals tend to learn to live with deficiencies and in time accept them as normal. Some call this the "can do" spirit. The point is that in taking this survey you are being asked to <u>carefully reflect upon your capacity to perform in your cockpit and try to identify everything that bothers you, even though it may be minor.</u> Your ratings of severity and criticality for each item will indicate the degree to which you think it is a problem. An item which may constitute only a nuisance to you because you have overcome it, may present a serious problem to someone else.

The words "control" and "display" are used often in this survey. They are general terms and for the purposes of this survey are defined as follows:

<u>CONTROL</u>

Any stick, push button, thumbwheel, knob, pull handle, toggle switch, rotary switch, pedal, crank, lever, handwheel, etc., which is used by a human operator to

control something in the cockpit.

DISPLAY

Any cathode ray tube, gage, tape, signal light, instrument, instrument face, label, etc., which provides some type of visual information to the human operator.

Don't rush through this survey. It may get tedious in spots but for the most part the questions are of the type which should have been asked years ago and should be of interest to you.

Because this questionnaire has been written for pilots and NFO's and for every aircraft imaginable it is necessarily general. If you feel that particular questions are too general and that valuable data is going to go uncollected then make some specific criticisms on the last page in the area reserved for general comments.

Please note that you are not asked to identify yourself at any point in this survey. This has been done in order to make you feel secure in the knowledge that any adverse comments you make can never be backtracked to you. The final analysis will be looking at groups, not individuals.

Also note that the originators of this survey are not under the illusion that this survey and the results thereof will be a cureall for Naval Aviation Safety's ills. The originators do, however, expect to get from this survey a valuable data base which may then be used to work toward a short term goal of eliminating serious design deficiencies in present aircraft cockpits and a longterm goal of designing System Safety and Human Factors Engineering into the cockpit at the design stage.

Please fill in the blanks in the following questions before continuing with the survey. this data will be used in the analysis portion of the project.

Date__________ Squadron____________

Are you a pilot or NFO (circle one)

Type aircraft you currently fly and which you are critiqing in this survey.____________

Hours in that type aircraft(approx.)____________

Total flight hours(approx.)______________

CONTROLS AND PRIMARILY TACTILE FUNCTIONS

This section applies primarily to controls. As noted previously, types of controls include sticks, push buttons, thumbwheels, knobs, handles, toggle switches, rotary switches, cranks, levers, pedals, handwheels, etc. In answering these questions try to put yourself mentally into the seat which you normally occupy in flight and visualize the problems you have or have had in the past.

1. Do you feel that the controls in your cockpit are <u>well placed</u> from the standpoint that the more important and more used controls are given preferential locations over controls that are less used and not as critical? (Do you find yourself frequently reaching across the cockpit for something which should be better located?) If you feel there are any problems in this regard note the control and problem or just comment generally below. Pay particular attention to emergency controls.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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2. Are you aware of any controls that are located or designed such that they stand a reasonably good chance of being inadvertently actuated by your elbow, forearm, side of hand, flight suit sleeve, knee, etc., as you are doing something else? If so, please identify the control and the type problem it presents.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY

3. Vibration as well as excessive G-forces sometimes have a tendency to change power settings or other control positions without the operator becoming fully aware. Is this a problem with any of your controls? If so, please so comment below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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4. Do you have any controls which you consider poorly designed because they have too many functions on one switch or have diverse unrelated functions on the same switch? If this type of problem exists then identify the problem below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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5. Some controls which govern sequential type operations are detented such that one can proceed in a logical fashion from one step to another. If you have any detented controls and you have problems with them please identify them below.

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6. Do you find that operation of a particular control or controls tends to be vertigo inducing? If so, please note the control and phase of flight.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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7. Are the controls in your cockpit standardized; ie, pushing up on a toggle switch should turn things on, clockwise on a knob should increase whatever the knob controls? If you find that you continually try to do something "backwards" with a control, it is a pretty good bet that the control is non-standard. Remember, controls include buttons, switches, pull handles, pedals, knobs, thumbwheels, etc.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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8. Do you feel that the functions you perform routinely in flight are balanced sufficiently between right and left hands? There might be a problem if quite a few things are being done by one hand such that that hand is overloaded while the other is often free. If you have strong feelings about this comment briefly below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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9. Are you required to operate any controls which are so complex or "tricky" to operate that they constitute a problem? Identify any such controls and the associated problem below.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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10. Think specifically of emergency procedures. Do any of these require manipulations of switches and controls or sequencing of actions which, in your opinion, are too complex and time consuming? If so, please identify the problem below.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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11. Do you have any controls which you find physically difficult to operate because of the excessive force required? Pedals, pull handles, etc., might fall into this category.

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12. Do you have any controls which are physically difficult to operate because of the awkward positioning movement required? Perhaps there is insufficient leverage, or an obstruction to movement which could cause this problem.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY

13. Do you have any controls which give you problems because they are difficult to adjust as precisely as required? If so, please note the problems below.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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14. Are you able to reach without difficulty all controls which you feel you need to reach while securely restrained in your seat as if for takeoff or landing? If not please identify those controls which present a problem.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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15. Are you able to reach without difficulty all controls which you feel you need to reach while in normal flight (not necessarily securely restrained). If not please identify those controls which present a problem.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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16. Can you think of any controls which require excessive visual attention in order to operate them properly? (you must spend too much time looking at that control or control-display interface as you actuate it when you should be monitoring other things. A control-display interface might be something like the control with which you check fuel quantity when you have numerous tanks but only one needle on the gage. If you need to hold a button or switch in a certain position too long while checking something then you may have a problem.) Identify any such problems below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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17. One way in which we receive information is via feedback through our tactile senses. Artificial feel in a control stick is an example. Can you think of any controls which lack this feel but which could be better operated with it incorporated?

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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18. Are there any problems in the area of foot operated controls such as rudder pedals and brakes? (Problems might be such things as too much pressure required, can't reach, foot slips off, etc.) Please identify any deficient controls and the problem below.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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19. Can you think of any situation wherein your primary means of identifying a particular control is by <u>feel</u> but there is another control in close proximity which is very similar and could easily be confused with the one you want? If you have ever in the past almost actuated the wrong control, it may have been the result of a problem such as this. Please identify any problems below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY

Although, in actuality, circuit breakers have a very important place in an aircraft cockpit they are often second citizens when it comes to finding a place to put them. Occasionally they are hard to operate and this, combined with intermittently having to stand on ones head to reach them, sometimes presents a problem. Please focus your attention on circuit breaker problems for the next few questions.

20. Do you have any difficulty in <u>identifying</u> specific circuit breakers when you have a need to check them, reset them, etc., because of lack of labeling or confusing labeling?

CB	PROBLEM	SEVER-ITY	CRITI-CALITY
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21. Are key circuit breakers located such that they are difficult to see or reach? Note whether the problem is in seeing, reaching, or both.

CB	PROBLEM	SEVER-ITY	CRITI-CALITY
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22. Do you have any physical problems in pulling and resetting circuit breakers as may be required? Do gang bar type circuit breakers present any particular problems? If so, identify the problem circuit breakers below.

CB	PROBLEM	SEVER-ITY	CRITI-CALITY
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HUMAN OPERATOR LIMITATIONS

As a consequence of your status as a member of the human race there are definite limitations on your capacity to perform specific physical and mental acts. But we find it difficult to admit to our limitations, in part because we don't really know what they are. One of the things which we encounter throughout our lifetimes and which we seldom consciously consider is a thing called negative transfer of training or, in short, negative transfer. Transfer of training refers to the way in which new learning is influenced by previous learning; negative transfer refers to a situation wherein previous learning interferes with new learning. (Of course positive transfer refers to the situation wherein what we have learned previously helps us to learn new material and this is what we strive for in our training programs.)

But let us take a look at negative transfer. Have you ever come across a light switch for which "up" turned the lights off, a set of water faucet controls with hot on the right and cold on the left, or a handle for a water faucet which had to be turned clockwise to get water? Most of us have encountered something like this at one time or another where it seems that a particular control or display "works backwords" or "works opposite to what it should". But the reason it appears to work backwords is that we have learned, to the point it has become habit, that light switches, water faucets, etc., work a particular way - - - the right way. Thus, if you are trying to learn to operate a light switch for which "down" is "on" you run into negative transfer in all its glory.

Another concept into which we seldom delve is that of the fact that when we are under stress, inattentive, or

fatigued we humans tend to revert to our <u>best learned response</u> to a particular stimulus. Thus, if we thoroughly learn how to operate the "backwards" light switch on the previous page, we will have a tendency to try to operate it the old way (the way we learned first and best) if we are required to operate it under stress. This same phenomena affects you in your flying. You learn many procedures and responses to the point of their becoming habit. Many emergency procedures are overlearned to the point that they become autcmatic. Unfortunately different aircraft sometimes require different procedures in response to the same stimuli. A certain control may be located in six different positions in as many aircraft cockpits. The fact that there are differences between aircraft and the fact that you need to overlearn some procedures, opens you up to the possibility that you will occasionally substitute a previously learned and incorrect response in an emergency situation.

Keeping in mind the concepts of "negative transfer" and "best learned response under stress" try to answer as best you can the following questions:

23. Can you think of any specific displays in your cockpit which operate oppositely from what you think they should or very differently from similar displays in another aircraft, such that you tend to occasionally misinterpret them? If so, do you think this is because of some previously learned means of interpreting a display which you just cannot unlearn or is it just a badly designed display? Note the display and problem below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY

24. Can you think of any specific <u>controls</u> in your cockpit which operate oppositely from what you think they should or very differently from similar controls in another aircraft, such that you tend to occasionally try to go the wrong way with them? If so, do you think you are being influenced by some previously learned means of operating a similar control which you just cannot unlearn? If so, list the control and problem below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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25. Under stress, when fatigued, or when inattentive have you ever caught yourself reaching for a control or looking for a display which does not exist in your cockpit. If so, you are probably responding as you would in another cockpit. If you have caught yourself doing that in your present aircraft please attempt to identify the control or display and the origin of the problem. Pay special attention to those items involved in emergency procedures.

DISPLAY CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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The Navy is becoming increasingly reliant on cockpit trainers and simulators to train and maintain the proficiency of aviators and NFO,s. If you have occasion to use such a device please answer the following question.

26. In your opinion does the trainer or simulator teach you bad habits in the way of setting up false conditioning or negative transfer. If so, comment below on the item and on how you feel it adversely affects your ability to respond properly in the real situation. Identify the training device or simulator.

DEVICE	PROBLEM	SEVER-ITY	CRITI-CALITY
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27. Forgetting is a very interesting aspect of human behavior. Gear-up landings and fuel starvation due to "forgotten" control activations are a fact of life in Naval aviation. No matter how much is said or done about the subject we continue to "forget" things. It is fact that the degree of attention you are able to give to something you want to remember, will have a lot to do with whether you do in fact remember it. Out of all the switches, controls, etc., you operate in the cockpit and all the things you need to monitor, can you think of any which stand out as being more easily forgotten than others? Please note that turning a switch on and forgetting it can be just as disasterous as forgetting to turn one on. Think of all those "forgetting errors" you've made in the past and identify the item forgotten and any other pertinent information below. Remember, this survey is totally anonymous.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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28. Just as we sometimes have no control over "forgetting" things which should not be forgotten, we sometimes have no control over our ignoring things which should not be ignored. An example comes from the airline industry where it has been suggested that a possible reason for commercial airline pilots unintentionally flying below decision height on an approach, in spite of a warning light which they have preset to illuminate at decision height, is that day and night, good weather and bad, the pilot sees that light come on. Since he sees it countless times and does not use it and since it is supplementary information to the barometric and radar altimeters in any event, the pilot by habit, at a time of high task load, learns to block this important signal from his awareness. Can you think of any situations which you encounter in your flying which may be similar to this in that you become conditioned to ignore important information because of the manner in which it is presented. If so, please describe briefly the situation and associated display.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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29. Do you have any displays or controls which are unreliable to the extent that you have become conditioned to expect them to be erroneous and thus have trouble convincing yourself to believe them when they are right? If so, please comment on this problem below.

DISPLAY CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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30. In the process of scanning an instrument panel you eventually build up the experience which allows you to know, without specifically focusing on a display, that it is generally in the "ballpark" when it is working properly. Once we become very familiar with a display we seldom look closely at its detail because the human mind no longer requires it. Are there warning devices built into your more critical instruments such that failure of the instrument will be immediately apparent to you? If you have to inspect the display closely to detect the failure then you have a problem. Identify any such problems below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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31. During critical phases of flight such as takeoff, low altitude manuevers, multiple aircraft rendezvous', approaches, and landings, are you ever bothered by distractions from inside the cockpit such as noises, lights, etc. If so, please identify the phase of flight and distraction below.

ITEM	PROBLEM	SEVER-ITY	CRITI-CALITY
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DISPLAYS AND PRIMARILY VISUAL FUNCTIONS

This section applies primarily to displays. As noted previously, types of displays include CRT's, gages, tapes, warning lights, instruments, instrument faces, labels, etc. Displays are anything which provide visual information to the human operator.

32. Do you feel that the displays in your cockpit are well placed from the standpoint that the more important and more used displays are given preferential treatment over displays that are less used and not as critical? If you feel there are any problems in this regard note the display and problem or just comment generally below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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33. Can you think of any displays which require too much of your attention either during normal flight or during a particular evolution? Perhaps the excessive attention you need to devote to this display keeps you from monitoring other equally important things. please note below the displays, if any, you consider to be a problem .

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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34. Are the displays in your cockpit sufficiently standardized as far as you are concerned; ie, circular gages have pointers which increase in a clockwise direction, tape movement upward corresponds to a numerical increase in the factor being measured? Identify problem displays below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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35. Are the more important displays in your cockpit sufficiently standardized in size such that they compete equally for your attention or is there an important display which is smaller and a problem because of its size? Please note any problem displays below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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36. Do you find that you have trouble getting information from displays because the displays vibrate excessively? If so, identify the display and the flight regime during which the problem is most pronounced.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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AT THIS POINT STOP AND CONSIDER WHAT YOU ARE DOING. Are you giving this questionnaire your best effort or are you going thru the motions? If you are going through the motions then STOP, relax for a few minutes, and then try again. Do your best to determine the ratings for severity (how physically or mentally difficult is the act of doing a particular thing?) and criticality (how unsafe is the problem?) as objectively as you can.

37. Do you experience any problems with glare on cckpit displays during daylight operations? Please identify the displays invclved below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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38. Do you have any parallax problem with regard to judging control settings? This type of problem might cause erroneous interpretation of rotary switch positions, because of the angle from which you view the control. Note any problem controls below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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39. Are you required to work with any controls (toggle switches, push buttons, pull handles,etc.) which you identify primarily by sight and which look similar, function similarly, are located near each other, in your opinion stand a reasonable chance of being mistaken for each other and yet have entirely different functions? (If you have ever reached for and actuated or almost actuated the wrong control then that combination probably constitutes a problem.) Fatigue, stress or inattention would contribute to a problem of this sort. Identify any such problems below.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY
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40. Can you think of any displays which are hard to interpret during night flight because of bad lighting? If you find yourself straining to read instruments at night, lighting quality or quantity could be the problem. Disregard glare effects - you have a shot at that in the next question.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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41. During night flight, does glare on instrument faces or from glass covers on instruments keep you from clearly seeing the display? Please identify any problems of this sort below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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42. Do you have an unobstructed view of all cockpit displays which you feel you need to see while securely restrained in your seat as if for takeoff or landing? If not, please identify the displays which present a problem.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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43. Do you have an unobstructed view of all cockpit displays which you feel you should be able to see while in normal flight (not necessarily securely restrained)? If not, please identify the displays which present a problem.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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44. Do you have any problems interpreting displays due to parallax problems? (this might involve displays which require precise interpretation but which are easily misinterpreted due to the angle from which you are forced to view them)

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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45. Many of the newer aircraft in the Navy inventory use cathode ray tubes as cockpit displays. Radar and television displays are the most common form of CRT's. Do you feel that you have adequate control over CRT brightness and/or other CRT features? (If it blinds you at night and cannot be seen in the bright of day you probably have a problem) Please identify the CRT and problem, if applicable.

DISPLAY	PROBLEM	SEVERITY	CRITICALITY
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One of the first things you learned in the training command was developement of an effective scan pattern for monitoring the instrument panel. The scan may vary from evolution tc evolution depending on the aircraft. The effectiveness of your scan can be helped or hindered by the way in which the various instruments are located in relation to each other, their proximity, relative brightness, etc. The following questions relate to this area.

46. Are displays grouped such that you are able to efficiently scan those you consider to be most important? Note problem displays below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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47. Are the displays you feel you need to include in your scan, illuminated at night such that they are all about equally easy to see and interpret? Please note problem displays below.

DISPLAY	PROBLEM	SEVERITY	CRITICALITY

48. Do the displays you feel you need to include in your scan compete equally for your attention? (Are some displays much larger than others and, if this is the case, does the larger one seem to dominate or is the smaller one equally attention getting?) Note any problems below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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49. Are the displays you feel you need to include in your scan equally easy to interpret such that you are not required to spend an excessive amount of time on one display at the expense of others? Note the problem displays, if any, below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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50. Can you think of any displays which are hard to interpret because of the confusing way in which the information is presented? (rather than glancing at this display and almost immediately getting the information, you must actually stop and take time to interpret what you see.) Please comment below on any problems of this type.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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51. Do you find that checking a particular display or displays tends to be vertigo inducing? If so, please identify the display and phase of flight.

DISPLAY CONTROL	PROBLEM	SEVERITY	CRITICALITY
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52. Is the information your displays give you sufficiently detailed? (If you need to know engine temperature to the nearest degree or altitude to the nearest foot, do the displays give you that or must you interpolate?) Are your displays telling you everything you need to know or do they give it to you in pieces and make you do mental calculations when your mind would be better off flying the airplane? List below any problem displays and briefly identify the problem.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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53. The last question was concerned with whether your displays gave you sufficiently detailed information. This one looks for the opposite situation. Do you have any displays which, in your opinion, provide excessively detailed information when in fact that amount of detail is not required? Note any problems below.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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54. Visual warning systems such as fire warning lights, caution lights, and annunciator panel lights should be very attention getting. Please note below any warning lights which you feel are not as attention getting as they should be and why. (Reasons might be too dim, should flash, wrong color, not in field of view, etc.)

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY

MISCELLANEOUS

This section comprises the "cats and dogs" of System Safety/Human Factors Engineering problems. The last question in this section gives you the opportunity to speak your mind on a wide range of topics. Do so.

55. Do you have any comments regarding the seat from which you operate. Comfort, ease of adjustment, range of adjustment, harness restraint system, ejection handle design and accessability, etc., could constitute potential problem areas. Please note any problems below.

ITEM	PROBLEM	SEVER-ITY	CRITI-CALITY
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IF YOU ARE A PILOT OF A SINGLE-SEAT AIRCRAFT OR IF YOUR AVIATING DUTIES IN A DUAL PILOTED AIRCRAFT ARE PRIMARILY LEFT SEAT, SKIP TO QUESTION 60.

This series of four questions involves the design of the co-pilot or NFO's seat in a side-by-side cockpit arrangement(A-6, E-2, S-3, P-3, etc) and the NFO's seat in aircraft such as the F-4 or F-14. the purpose of the questions is to determine those critical controls and/or displays which are not accessable enough or not accessable at all to you, the co-pilot or NFO, who need them to fulfill your responsibility of backing-up the pilot.

56. List those controls which you can operate only with great difficulty (you can get to them, but not very easily) but which you feel should be more accessable.

CONTROL	PROBLEM	SEVER-ITY	CRITI-CALITY

57. List those controls which you cannot operate at all (you can't get to them at all) but which you feel you should be able to operate.

CONTROL	PROBLEM	SEVERITY	CRITICALITY
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58. List those displays which you can monitor only with great difficulty but which you feel should be more easily monitored.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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59. List those displays which you cannot monitor at all but which you feel you should be able to monitor.

DISPLAY	PROBLEM	SEVER-ITY	CRITI-CALITY
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60. The problems of lack of stowage space in the cockpit often arises. If you have strong feelings on this topic please comment below.

PROBLEM	SEVERITY	CRITICALITY

61. Aural warning systems are sometimes used in place of or as backups for visual warning systems. Examples are the tone which goes off when you go below preset radar altimeter limits and the various ECM warning signals. If you are aware of any problems in this area such as signals being too weak, not attention getting enough, too loud, etc., please identify them below.

SYSTEM	PROBLEM	SEVER-ITY	CRITI-CALITY
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62. Do you have sufficient control over floodlight and peripheral lighting so as to be able to easily adjust the lights to a level you find comfortable? Do not consider instrument and control panel lighting. If, in your opinion, there are problems, please note below the offending light or lights and the type problem (too bright, too dim, can't adjust, bad location, glare, etc.).

SYSTEM	PROBLEM	SEVERITY	CRITICALITY
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63. Do you have sufficient control over the instrument and console lighting so as to be able to adjust these lights to a level you deem comfortable? A situation where you had to live with a bright panel or instrument next to a dim one might cause a problem. Identify any problems below.

SYSTEM	PROBLEM	SEVER-ITY	CRITI-CALITY
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64. If you have any general comments on the transition back and forth between simulators and actual aircraft please make them in the space below.

65. Do you have any comments regarding the environmental conditions in which you are required to work? Environmental factors can cause distraction and induce fatigue. They include such things as temperature, vibration, illumination, noise, humidity, pollution, etc. If any of these factors present a significant problem in your cockpit please identify the problem below.

FACTOR	PROBLEM	SEVERITY	CRITICALITY
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66. This page and the following one are provided for you to expound to your hearts content as to your opinion of this questionnaire, your view of SS/HFE and its role in your future, your biggest complaint with regard to Naval Aviation Safety, etc. In other words you are being asked to unload, in the name of research, any pent up observations you have. Have at 'em.

SEVERITY AND CRITICALITY RATING SHEET

You are asked to rate deficiency severity and criticality numerous times within this questionnaire. The scale ranges from 1 to 5 with the higher numbers indicating increased severity and criticality. In order to provide clarification of the meaning of each rating the following interpretation is provided:

SEVERITY-The difficulty the named deficiency presents to the operator.

Rating	Reaching, seeing, interpreting, etc., this control or display or performing this act, in my opinion,
1	is not at all difficult or only slightly so
2	is somewhat difficult
3	is quite difficult
4	is extremely difficult
5	is impossible or nearly so

CRITICALITY-The potential of the named deficiency for causing an accident or serious incident.

Rating	Reaching, seeing, interpreting, etc., this control or display or performing this act, in my opinion,
1	has virtually no effect on flight safety
2	has some potential for causing an accident or serious incident
3	has considerable potential for causing an accident or serious incident
4	has great potential for causing an accident or serious incident
5	either already has caused an accident or serious incident or will cause one in the near future

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